SINTERED COMPOSITE MATERIAL, A PROCESS OF MAKING SAME, AND A METHOD OF USING SAME

CROSS-REFERENCE TO RELATED APPLICATION

This is a continuation, of application Ser. No. 506,610, filed Sept. 16, 1974, now abandoned.

The present application is related to copending applications Ser. No. 471,891 of HEINZ BROEMER, HANS-HERBERT KAES, and EMANUAL PFEIL, filed May 21, 1974, and entitled "GLASS CERAMIC MATERIAL AND PROCESS OF MAKING AND USING SAME", now U.S. Pat. No. 3,922,155, and Ser. No. 471,976 of HANS-HERBERT KAES, filed May 21, 1974, and entitled "GLASS CERAMIC MATERIAL OF HIGH MECHANICAL STRENGTH AND PROCESS OF MAKING SAME," now abandoned, which applications are incorporated by reference into the present specification.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to the manufacture of a composite or compound material and more particularly to a simple and highly advantageous sintering process for producing a glass-ceramic composite material, to such a composite material, and to the method of using it more particularly in medico-engineering, such as for osteosynthesis.

(2) Description of the Prior Art

It is known that glass-ceramic materials which contain apatite crystallites can be used as bone replacement materials. However, such a glass-ceramic material has the disadvantage that it must be manufactured via a melt. Furthermore, useful glass ceramics for said special purpose of use are obtained only by starting with certain exactly defined components of the starting mixture in exactly predetermined amounts thereof.

SUMMARY OF THE INVENTION

It is one object of the present invention to provide a simple and highly advantageous sintering process which does not have the disadvantages of the heretofore used melting process and by which a composite or compound material having the structure of apatite-containing glass ceramics is produced.

Another object of the present invention is to provide such a sinter-produced composite material.

A further object of the present invention is to provide a method of using such a sinter-produced composite material especially in the medico-engineering field, for instance, for replacing bones and teeth (osteosynthesis) and for other purposes.

Other objects of the present invention and advantageous features thereof will become apparent as the description proceeds.

These objects are achieved according to the present invention by carrying out the sintering process as follows:

A first starting material A comprising at least one mineral component is sintered together with a second starting material B consisting of an inorganic multi-component or complex system. In this connection it can be advantageous to grind and mix the two starting materials A and B before they are sintered together. The mineral component of the starting material A may be a natural or synthetic mineral of the apatite group ($Ca_5[(F, Cl, OH)(PO_4)_3]$). It is also possible to use an apatite prepared by precipitation and having a disturbed crystal lattice structure.

The inorganic multi-component system of the starting material B can be a glass, a mixture of components which can be fused together to form a glass, a glass-ceramic material, or a mixture of components which can be fused together to form a glass-ceramic material.

Preferably the mixture consisting of said two starting materials A and B additionally contains at least one modifier. Such a modifier affects, i.e., modifies in a predetermined manner the properties of the resulting composite material, for instance, by loosening up its structure or by inflating or expanding the same. Compounds which are capable of releasing gases under the temperature-time adjusted sintering conditions, i.e., under the respective "sintering timetable," can be used as modifiers. Preferred modifiers are the carbonates of the alkali metals and alkaline earth metals, especially calcium carbonate ($CaCO_3$). The nitrates and hydrogen carbonates of the alkali metals or alkaline earth metals can also be added as modifiers; likewise, although less advantageously, the sulfates of such metals of the first and second group of the Periodic System. Not only a single modifier can be added to the starting materials A and B but also a mixture thereof. Addition of such modifiers results in a permanent formation of gas bubbles under the specific temperature-time conditions of the sintering process. The gas bubbles cannot escape from the resulting sintered composite material due to its viscosity. Thus the final composite material is highly porous, i.e., its specific surface is very considerably enlarged.

Radioactive compounds such as potassium carbonate with the radioactive isotope ^{41}K can also be added as modifiers.

It is also possible to replace the mineral component forming the first starting material A in whole or in part by another or additional mineral component. For instance, such other additional mineral component may be a mineral of the permutite group, such as a permutite of the formula $Na[AlSiO_4].H_2O$.

The sintering process of the present invention permits to produce composite materials of any desired composition and to start from previously prepared base materials. This proves to be of great advantage specifically when using the minerals of the apatite group since it is thus no longer necessary to start with components corresponding stoichiometrically to the apatite structure which then precipitates or separates spontaneously from the base glass. It is also possible in a predetermined manner to incorporate other apatites such as, for instance, chlorapatite ($Ca_5[Cl(PO_4)_3]$) and/or hydroxylapatite ($Ca_5[OH(PO_4)_3]$).

Furthermore, the sintering process of the present invention allows to use for synthesizing or producing the desired composite material well-crystallized apatites or, respectively, apatites of disturbed crystal structure such as they can be obtained, for instance, by precipitation.

According to an advantageous embodiment of the present invention, the sintering process proceeds in accordance with the following four process steps:

Step (a) The two starting materials A and B are ground, preferably jointly, for instance, in a ball mill, to